APPENDIX B
DESIGN AND INSTALLATION OF MONITORING WELLS

PERFORMANCE OBJECTIVES:

- Ensure that monitoring wells provide groundwater samples that are representative of aquifer conditions.
- Ensure that monitoring wells are constructed properly and will last the duration of the project.
- Ensure that monitoring wells will not serve as conduits for contaminants to migrate between aquifers.

Introduction

This appendix describes methods and procedures for the design and construction of permanent and temporary monitoring wells installed for collecting groundwater samples for analysis. The procedures contained in this appendix are to be used by field personnel when designing, constructing and installing groundwater monitoring wells. On the occasion that field personnel determine that any of the procedures described in this section are either inappropriate, inadequate or impractical, and that another procedure must be used for any aspect of the design, construction and/or installation of a groundwater monitoring well, the variant procedure will be documented in the field log book, along with a description of the circumstances requiring its use.

B.1 Drilling Methods

The preferred drilling methods for installing monitoring wells are those that temporarily case the borehole during drilling and construction of the well. When site conditions are not suitable for these drilling methods, alternate methods should be selected that will perform the job equally well.

B.2 Borehole Construction

B.2.1 Annular Space

The borehole or hollow stem auger should be of sufficient diameter to allow for proper well construction.

For open boreholes, the annular space should allow the placement of the screen and riser, tremie pipe (minimum ¾"), and filter material, bentonite pellets (seal), and grout without disturbing the borehole wall. Approximately 1.5" of annular space around the screen and riser will allow the uniform placement of well materials using a tremie pipe. For example, a 2" inside diameter (I.D.) casing would require a 6" I.D. borehole.

For hollow stem augers and sonic method drill casing, the I.D. should be of sufficient size to allow the free passage of filter sands and bentonite pellets dropped through the auger or casing and to allow the use of a tremie pipe for placement of grout. For example, a 4 ¼" I.D. should be the minimum size used for placement of 2" I.D. casing and 8 ¼" I.D. for 4" I.D. casing.

B.2.2 Overdrilling the Borehole

It may be necessary to overdrill the borehole if it is anticipated that material from the augers during removal or the bottom plug will remain in the borehole. Normally, 3 to 5 feet is sufficient. If the borehole is drilled deeper than desired, it can be backfilled to the design depth with bentonite pellets, bentonite chips, or filter pack sand. Overdrilling may also be used to create a sump area for the placement of a catch basin or storage area of additional well casing attached below the well screen, designed to "catch" the sediment that drops out of suspension in aquifers that are naturally turbid and will not yield clear sediment-free water after extensive development.

B.3 Well Construction Materials

B.3.1 Well Screen and Casing Materials

The minimum casing size for permanent wells will be 2" I.D. to provide access for sampling equipment.

Screen length should be selected based on the formation to be monitored. For formations less than 50 feet thick, a maximum 10-foot screen length is appropriate. Screen lengths exceeding 10 feet may result in diluted water samples. Appropriate slot sizes should be selected based on formation materials and the slot opening should retain 90 percent of the filter pack material.

Well casing material should be of sufficient strength to withstand installation and maintain integrity for the duration of the monitoring period. Casing material should be made of material that will not contribute constituents or remove chemicals of concern.

B.3.2 Filter Pack Materials

Filter pack sand (materials) should be clean, well-sorted, hard, of uniform size and, insoluble siliceous composition. Particle sizes should be based on sieve analysis and a grain-size distribution and should minimize head loss and prevent sediment migration into the well. If sufficient data is available to adequately design the well screen and filter pack then a sieve analysis may not be necessary. Proper documentation should be available for composition, grain-size distribution, cleaning procedure, and chemical analysis.

B.3.3 Filter Pack Seal-Bentonite Seal (Plug)

Bentonite pellets consist of ground, dried bentonite compacted into pellets. A properly hydrated bentonite pellet seal with a minimum thickness of 12 inches directly above the filter pack is necessary. A 24-inch thickness is recommended.

B.3.4 Grout

The annular space between the casing and the borehole wall above the bentonite seal should be filled with a neat cement grout, a cement/bentonite grout, or a high solids sodium bentonite grout. Other materials such as drilling muds are not acceptable as grout.

B.4 Well Installation

B.4.1 Well Screen and Casing Placement

A minimum of 6 inches of the filter pack material should be placed in the bottom of the borehole under the well screen to provide a firm footing and an unrestricted flow of water under the well screen. The string of well screen and casing should be placed through the hollow stem augers or directly into the borehole.

B.4.2 Filter Pack Placement

The filter pack sand should be emplaced through the augers or tremie to the target depth around the well screen. The filter pack should extend at least 2 feet, but not more than 3 feet, above the well screen, to allow for settling and to isolate the screened interval. If using hollow stem augers, the augers should be withdrawn slowly during placement of the filter pack to avoid bridging and to insure that the annular space is filled properly. During withdrawal of the augers or tremie, a weighted tag line should be used to insure proper placement of the filter pack.

B.4.3 Bentonite Seal Placement

The bentonite seal should be placed directly on top of the filter pack to an un-hydrated thickness of 2 feet using a tremie pipe. The pellet seal should be hydrated with potable water for 24 hours or per the manufacturer's specifications.

B.4.4 Grouting the Annular Space

Grout should be placed in the borehole using forced injection. The tremie should be lowered to the bottom of the zone to be grouted and should be kept full continuously from start to finish of the grouting procedure, with the discharge end of the tremie being continuously submerged in the grout until the zone is completely full. Grout should be placed from the top of the bentonite seal to within 2-feet of the ground surface. Grouting should not disturb the bentonite seal or filter pack. Grout should be allowed to cure for 24 hours or per the manufacturer's specifications before the concrete surface pad and protective casing is installed.

B.5 Surface Pad and Protective Casing

The surface pad should be constructed of concrete or aggregate reinforced cement of sufficient strength and durability appropriate to the setting and location should be installed. At a minimum, for a 2" I.D. well, the well pad should be 3'x3'x 4"and for a 4"I.D. well, the well pad should be 4'x4'x6". The finished pad should be slightly sloped to allow water drainage away from the protective casing and off the pad.

In non-traffic areas, above-ground completion is preferred. A protective outer casing of corrosion-resistant material with a locking cap and weep holes should be installed to a height of at least 3 feet and painted with a highly visible enamel paint.

Flush-mounted wells may be installed in parking areas, roadways, or areas that are mowed. The protective vault should be installed around a well casing fitted with a protective cap that is cut below grade. The vault should be water tight and set slightly above grade to prevent surface runoff from entering the vault.

B.6 Telescoping/Multi-Cased Wells

Double-cased wells are appropriate to prevent cross-contamination, to seal off highly contaminated surface soil, or in situations where flowing sands prevent the installation of an open borehole.

The pilot borehole should be of sufficient diameter to accommodate the outer casing and a minimum 2" annular space. The inside diameter of the outer casing should be sufficient to contain the inner casing and the minimum annular space.

The pilot borehole should be bored through the overburden or contaminated zone and into a confining layer, bedrock, or uncontaminated zone. The casing and grout should extend into a confining unit of tight clay at least two feet and into competent bedrock at least one foot. The total depths will vary depending on the plasticity of the clay and the weathering and /or fracturing of the bedrock. The project geologist should approve the final depth.

The outer casing should be placed into the borehole and pressure grouted with an approvable grout. The grout should cure for a minimum of 24 hours prior to drilling through it. When drilling through the seal, drilling activities should not cause damage to the seal.

B.7 Well Development

Wells should not be developed within 24 hours of completion of the surface pad and protective casing to allow sufficient time for the well materials to cure. Regardless of drilling methods, all wells must be developed to remove the residual materials and to re-establish the natural hydraulic flow conditions of the formation which were disturbed by well construction. A new monitoring well should be developed until the column of water is free of visible sediment and the temperature, pH, turbidity, and specific conductivity measurements have stabilized. In some cases water may remain turbid after all parameters have stabilized. In this is the case, the well may need continuous flushing over a period of several days. To insure that the formation has re-stabilized to pre-well conditions, at least 24 hours should be allowed to elapse prior to sampling a new well, or a newly developed well. Wells developed with more stressful measures may require longer intervals between development and sampling.

B.8 Well Abandonment

Proper well abandonment should insure the borehole will not act as a conduit for migration of contaminants. The abandonment procedure should be based on geology, well casing materials, condition of the well, confidence in the original well construction practice, protection of drinking water, and future property use. It is preferred that the well casing and screen be completely removed from the borehole, and the borehole cleaned and pressure grouted from the bottom of the borehole to ground surface. Wells may also be grouted with the casing in the borehole. The tremie should be placed in the bottom sump area or screen and pressure grouted. The grout should be forced out through the well screen into the filter material and up the inside of the well casing sealing all holes and breaks that are present. Damaged wells may require over-drilling to remove damaged casing and screen, and pressure grouting from the bottom of the borehole to the ground surface.

References

1. U.S. Environmental Protection Agency, Region IV, Science and Ecosystem Support Division, Design and Installation of Monitoring Wells, February 2008, (SESDPROC-205-R1).
2. U.S. Environmental Protection Agency, Region IV, Design and Installation of Monitoring Wells, November 2001.
3. S.C. Department of Health and Environmental Control, R.61-71, South Carolina Well Standards, 2002, (Supp. 2007).
4. 4.ASTM, Standard Practice for Design and Installation of Groundwater Monitoring Wells in Aquifers (D5092-04)
5. Nielsen, D.M., "Correct Well Design Improves Monitoring", Environmental Protection, **4**.38-49, 1993.